[redacted]

Lam RESEARCH

INTELLECTUAL PROPERTY DEPARTMENT RECEIVED
AUG 01 2000

Invention Disclosure

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Date: 07/31/00

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1a. Project Name: Use of Ammonia (NH3) for Etching SiLK®, an organic Low-k Dielectric.

1b. Technology: Dielectric Etch

1c. Business: (Circle One) •Conductor Etch •Dielectric Etch •CMP •Clean •New Product Development •Platform Engineering •Software
Other _____

1d. Lam Product(s): Exelan-HP

2. Title or subject matter of your invention:

Use of Ammonia (NH3) for Etching SiLK, an organic Low-k Dielectric.

3. Please attach a brief, yet thorough, description of what your invention is and how your invention operates or performs. Describe the preferred and alternative ways in which your invention would be implemented. Attach and identify copies of all known drawings, sketches, (flow-charts for software), formulae, descriptions, data, articles, etc., of your invention, including copies of your lab notebook entries (dated and witnessed).

NH3 is used to etch SiLK, an organic low-k dielectric. NH3 is used because it has a much lower ionization potential than traditional etchants of SiLK, such as N2/H2. Because of the lower ionization potential, higher plasma density and higher SiLK etch rate can be achieved using NH3 rather than N2/H2 for the same process conditions. In addition, the NH3 plasma is much more stable than a N2/H2 plasma, given the same processing condition. We believe that where there is insufficient ion bombardment, such as on the sidewalls of the Vias/Trenches, NH3 reacts with the SiLK and forms a polymer consisting of (=CH-N=)n groups arranged in a 3-dimensional matrix. The HCN polymer passivates the sidewall and prevents profile bowing.

4a. Describe any prior art (e.g., known existing products, methods, publications or patents) of which you are aware and which relate to your invention:

4b. State in detail the advantages that your invention has over this prior art and how your invention distinguishes over this prior art:

The use of NH3 has many advantages over prior chemistries for etching SiLK. NH3 has a much lower ionization potential than N2, a component of prior chemistries used for etching SiLK; this leads to the following advantages over other traditional methods for etching SiLK:

- Higher SiLK etch rates, about 2.5 times higher etch rate than using N2/H2 chemistry.
- Profile angle is independent of feature size. All feature sizes show very similar profile angles.
- Forms an HCN-type polymer on the sidewall of the SiLK Via/Trench structures which passivates the sidewalls to prevent profile bowing due to lateral etching/ion bombardment and also prevents poisoning of the structures due to outgassing of solvent from the SiLK during subsequent barrier metal deposition.
- Higher selectivity of SiLK to Oxide or Nitride hardmask materials.
- Allows for a more stable plasma over a wider pressure and power operations regime than N2 containing chemistries.

5. **Conception/Reduction/Commercial Use:**

Date of first conception: [redacted]

Date of first notebook entry [redacted]

Where conceived?: Fremont, CA

Was invention reduced to practice (made/used)? (yes/no): Yes
If yes, date first reduced: [redacted]

Is commercial or public use planned (yes/no): [redacted]
If yes, date of expected or actual public disclosure or offer for sale: [redacted]

Was invention result of co-development project with others? (yes/no): No
If yes, explain (include whether NDA in place):

6. **Did invention occur during performance of a government contract? (yes/no):** No
If yes, explain:

7. **Give names of other persons familiar with or who have worked on the project, but who do not claim an inventorship interest in the invention (please identify the project or intended product):**

Reza Sadjadi, Jim Tietz, John Lang, Rao Annapragada

8. For each inventor, please provide the following information (copy & paste as necessary):

8a. Legal Name (as you intend to sign application): Chok W. Ho

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Daniel Liao

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Citizenship: Taiwan

Names of Supervisor, Director, and Vice President: Alfred Tsai, Young-Tong Tsai Daniel Liao

9. **Inventor's Signature(s) and date signed:**

Charlie W. Ho 8/1/2000

10. **Witnessed & Understood By (include date):**

Rao Annaprogada 8/1/2000.

THIS FORM IS Lam RESEARCH NEED-TO-KNOW CONFIDENTIAL DATA WHEN FILLED IN. Please send the completed form to Intellectual Property Law Group, Lam Research Corp., Law Department, M/S CA1, 4650 Cushing Pkwy, Fremont CA 94538.

PROJECT: SILK ETCH USING NH_3

System	Exelan-HP	Module ID: 8302PM2
Engr:	CHOKW.HO	
Date:	050900	

ESC@0°C

LAM FLARE TEST WAFER

Section	Wafer ID	mT PRESS	(W) 27 MHZ	(W) 2 MHZ	Ar	N2	O2	CO	C4F8	CF4	CH2F2	CHF3	NH_3		(sec) TIME	(%) RMO	-Vdc	COMMENTS
		70	500	1K	160		15		5	40					30	39.7	461	MAY09-01.14X
		55	1400	1K	140		9		15						10	35.9	587	
		160	700	—	100								1000		10	—	—	
		160	700	—									1000		200	36.5	319	

* appears to have Endpointed @ [redacted] 103 sec. (Step 4)
* PR all removed @ [redacted] 70 sec. (Step 4)

01/18/04 md

2002 1/18

PROJECT: NH3 (SILK Etch)

System	Exelan-HP	Module ID:	8302
Engr:	CHOK W. HO		
Date:	05/18/00		

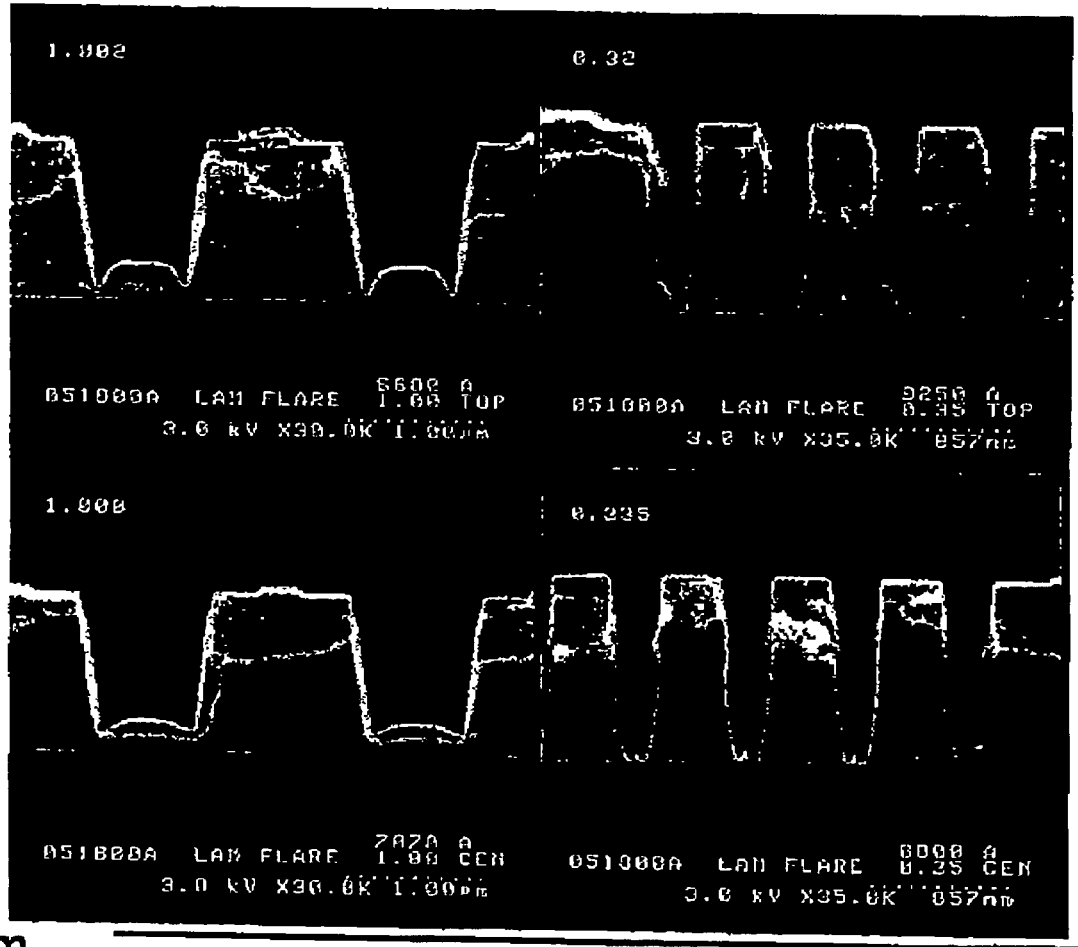
		mT	(W)	(W)	CHEMISTRY										(sec)	(%)		
Section	Wafer ID	PRESS	27 MHz	2 MHz	Ar	N2	O2	CO	C4F8	CF4	CH2F2	CHF3	NH3		TIME	RNG	-Vdc	COMMENTS
25	0518005A	70	500	1K	160		15		5	40					30	45.	480	ESC@-10°C
		55	1400	1K	140		9		15						10	35.7	590	
		160	700	—	·								1600		90	39.4	380	
24	0518005S	70	500	1K	160		15		5	40					30	44.6	450	ESC@-10°C
		55	1400	1K	140		9		15						10	34.8	542	May 18 - 01.04K
		~~160~~	~~700~~										600		130	36.5	328	
		100	500	—														
23	0518005C	70	500	1K	160		15		5	40					30			ESC@-10°C
		55	1400	1K	140		9		15						10			May 18 - 01.05K
		160	700	—									600		90	90	353	

EPP PLL

Dec 1/05

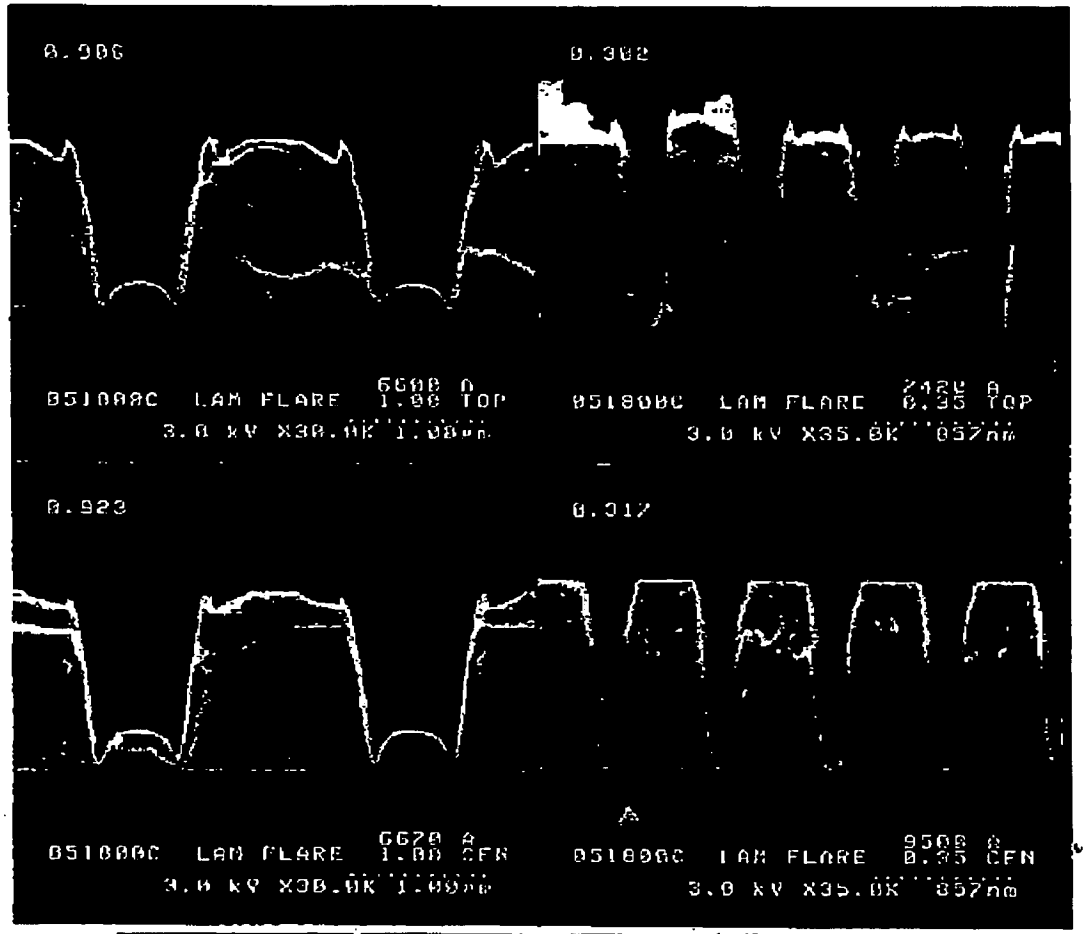
Wafer # 051800A (ESC @ - 10°C)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 30"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
160 mT/ 700/ 0/ 1000 NH3/ 90"

ER = 5269 A/min; ER Uniformity ≤ 3.4%; RIE Lag = - 40.1%



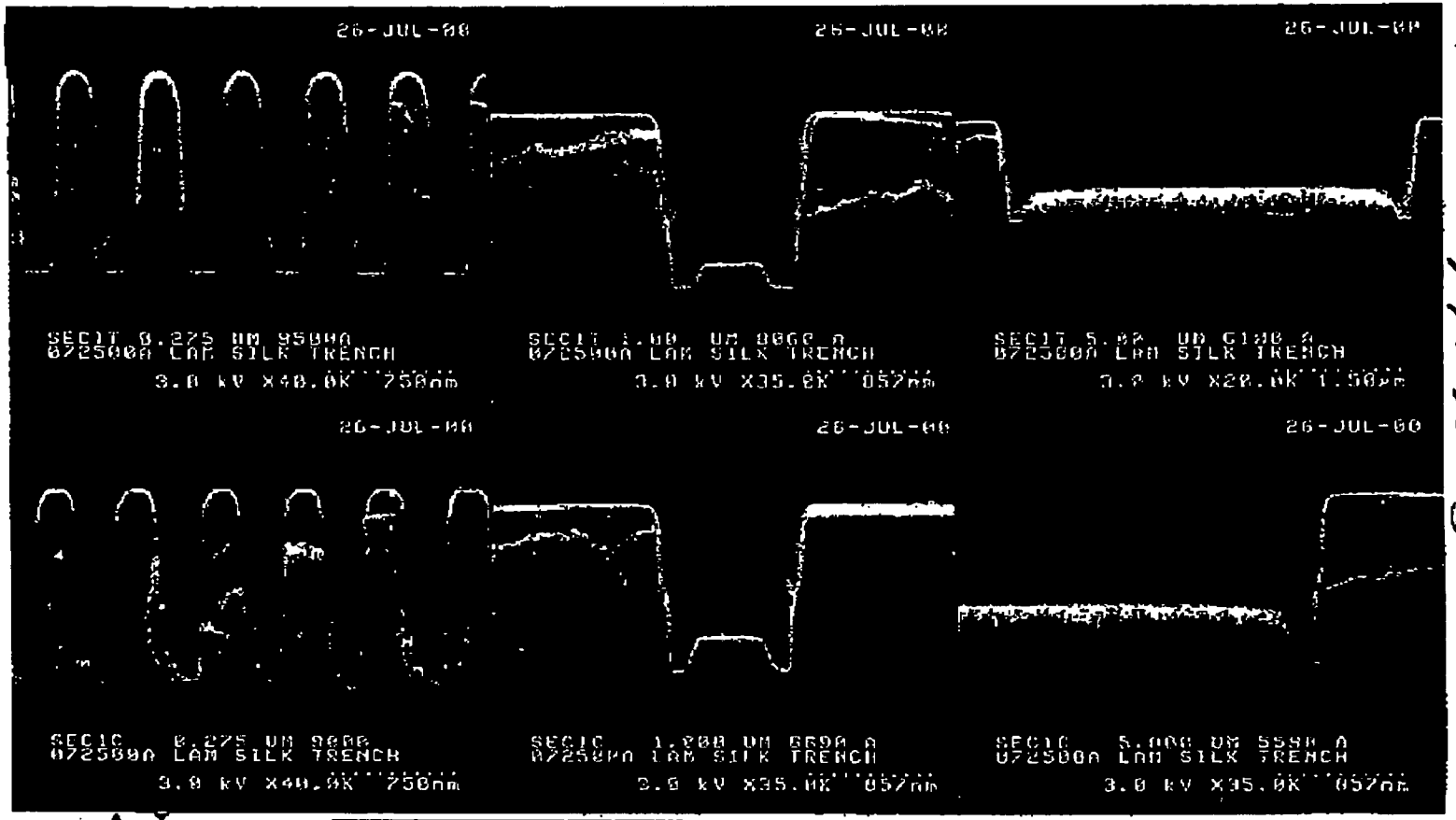
Wafer # 051800C (ESC @ - 10°C)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 30"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
160 mT/ 700/ 0/ 600 NH3/ 90"

ER = 5032 A/min; ER Uniformity ≤ 12.3%; RIE Lag = - 42.4%

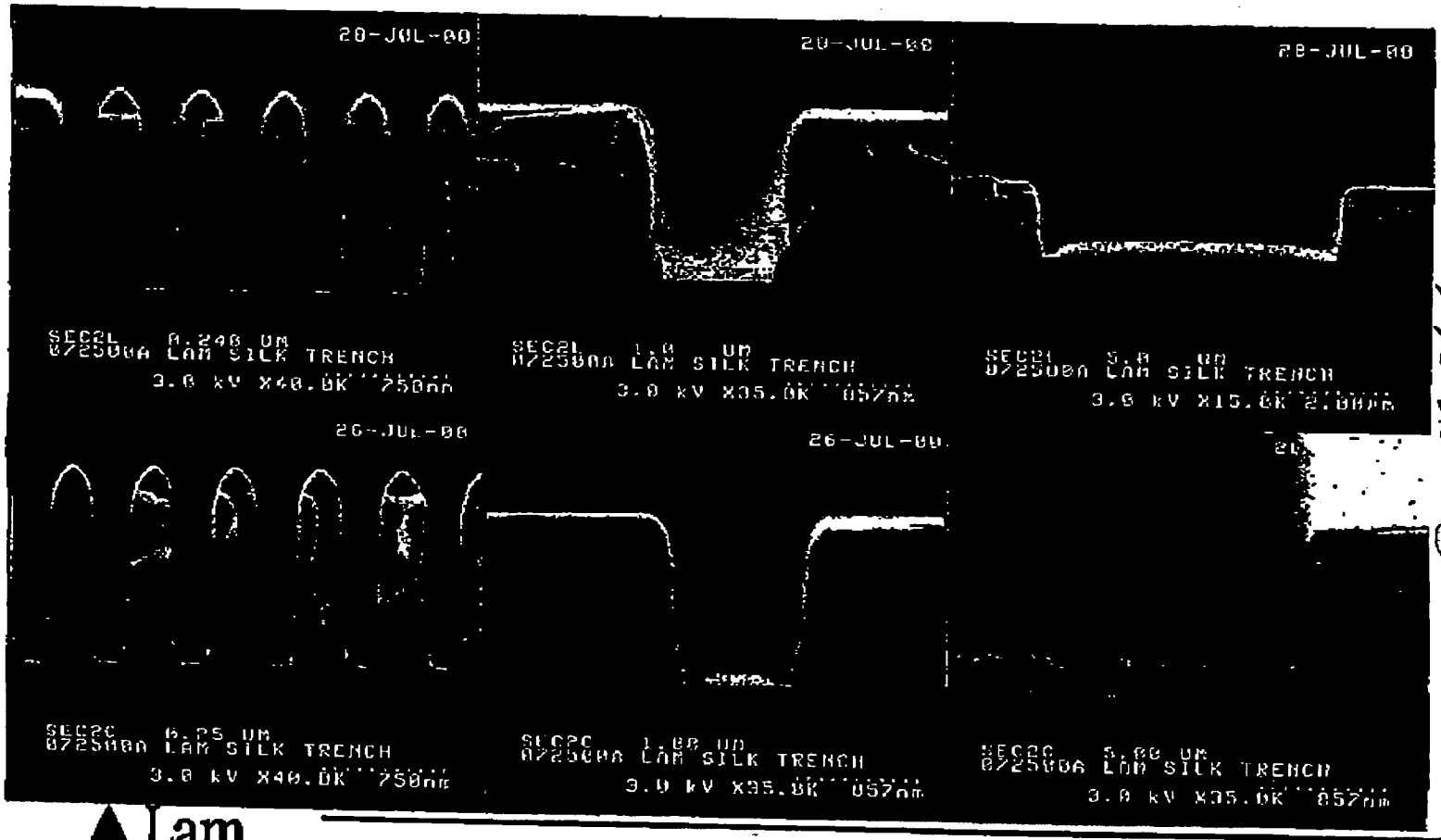


Wafer # 072500A (ESC @ 0°C) (Partial Etch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
60 mT/ 500/ 0/ 300 NH3/ 150"

ER = 3325 A/min; ER Uniformity ≤ 9.3%; RIE Lag = - 34.5%

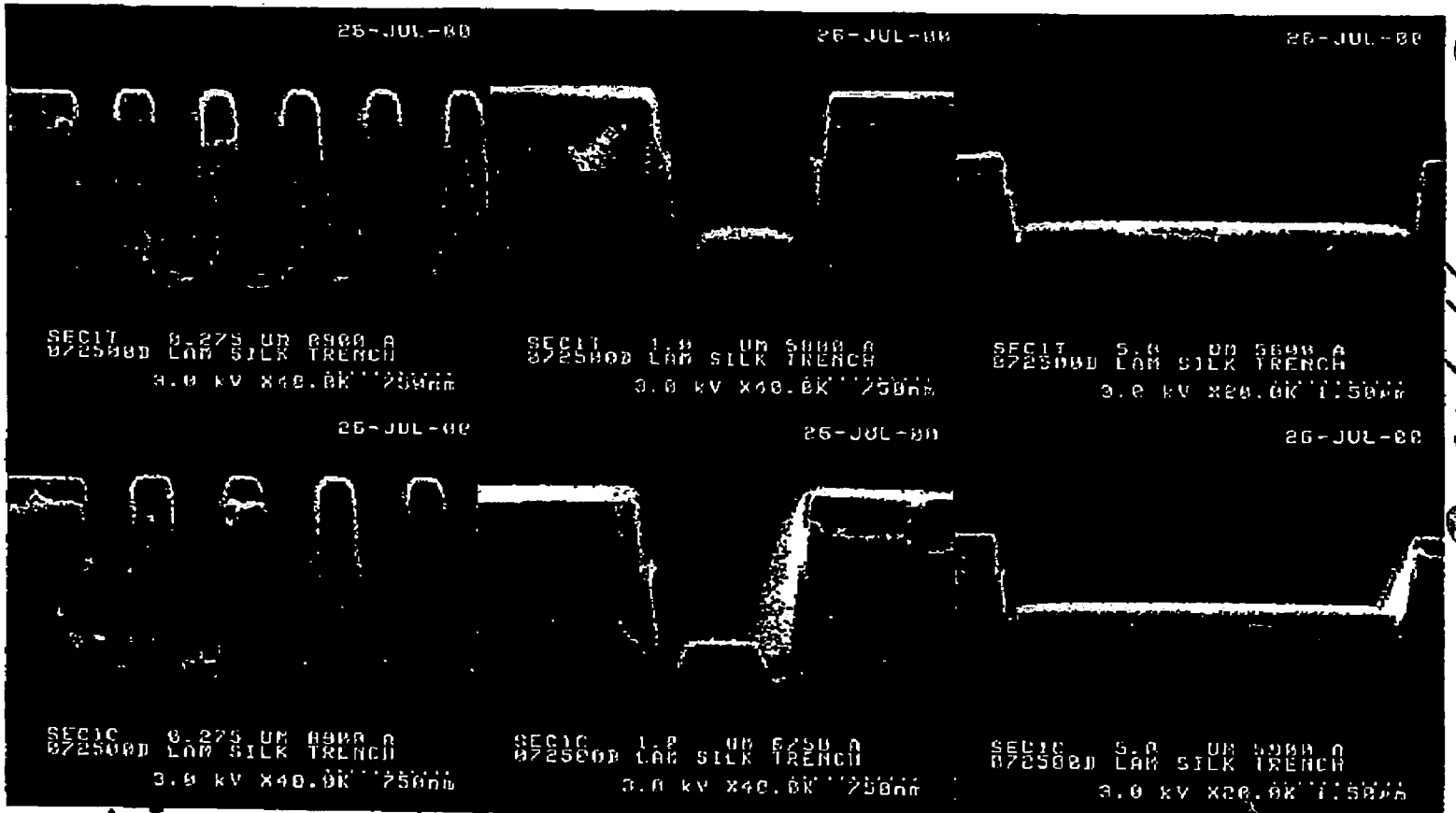


Wafer # 072500A (ESC @ 0°C) (57.5% Overetch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
60 mT/ 500/ 0/ 300 NH3/ 270"

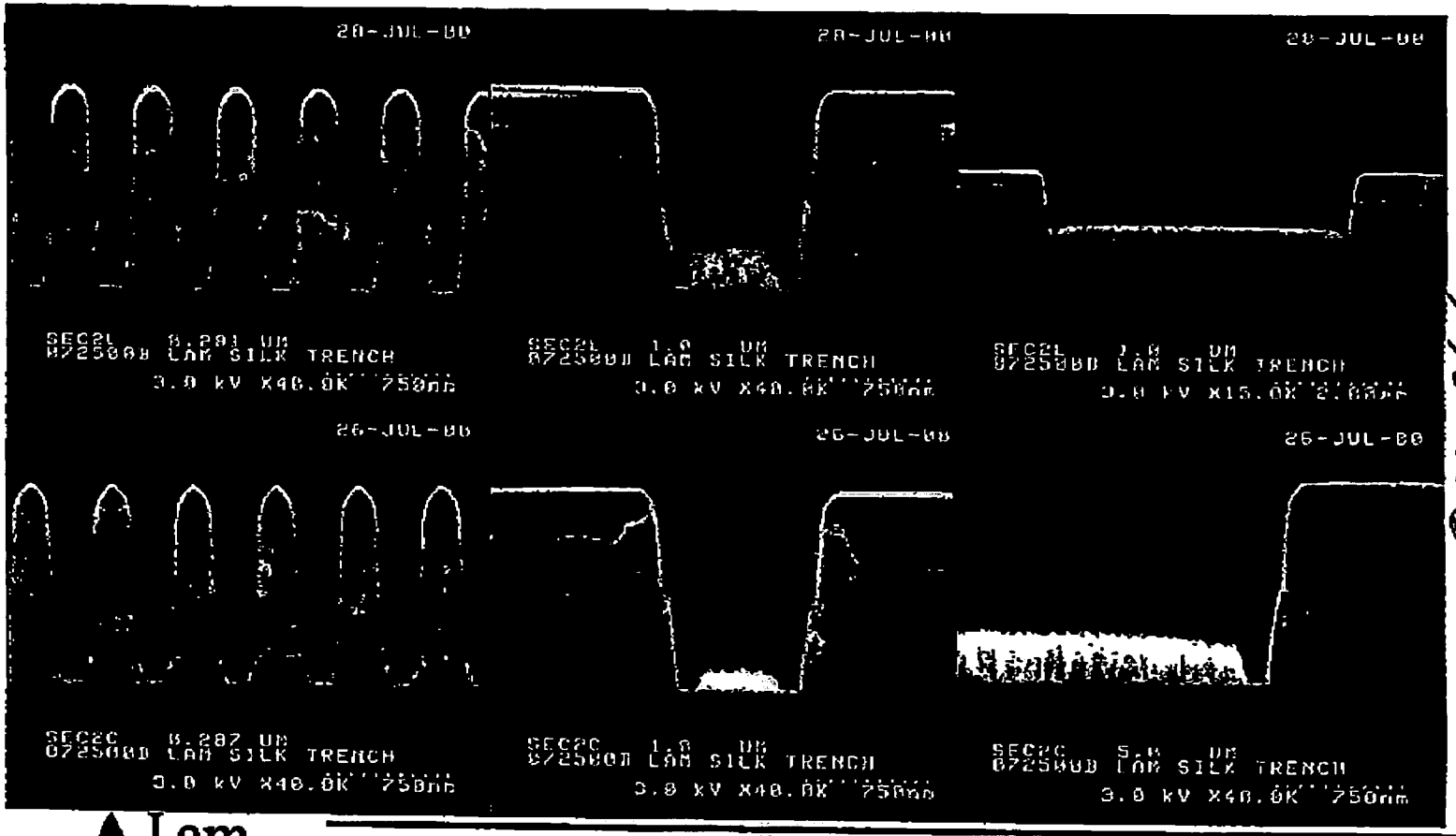


Wafer # 072500B (ESC @ 0°C) (Partial Etch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
160 mT/ 500/ 0/ 600 NH3/ 115"

ER = 3959 A/min; ER Uniformity ≤ 7.6%; RIE Lag = - 53.4%

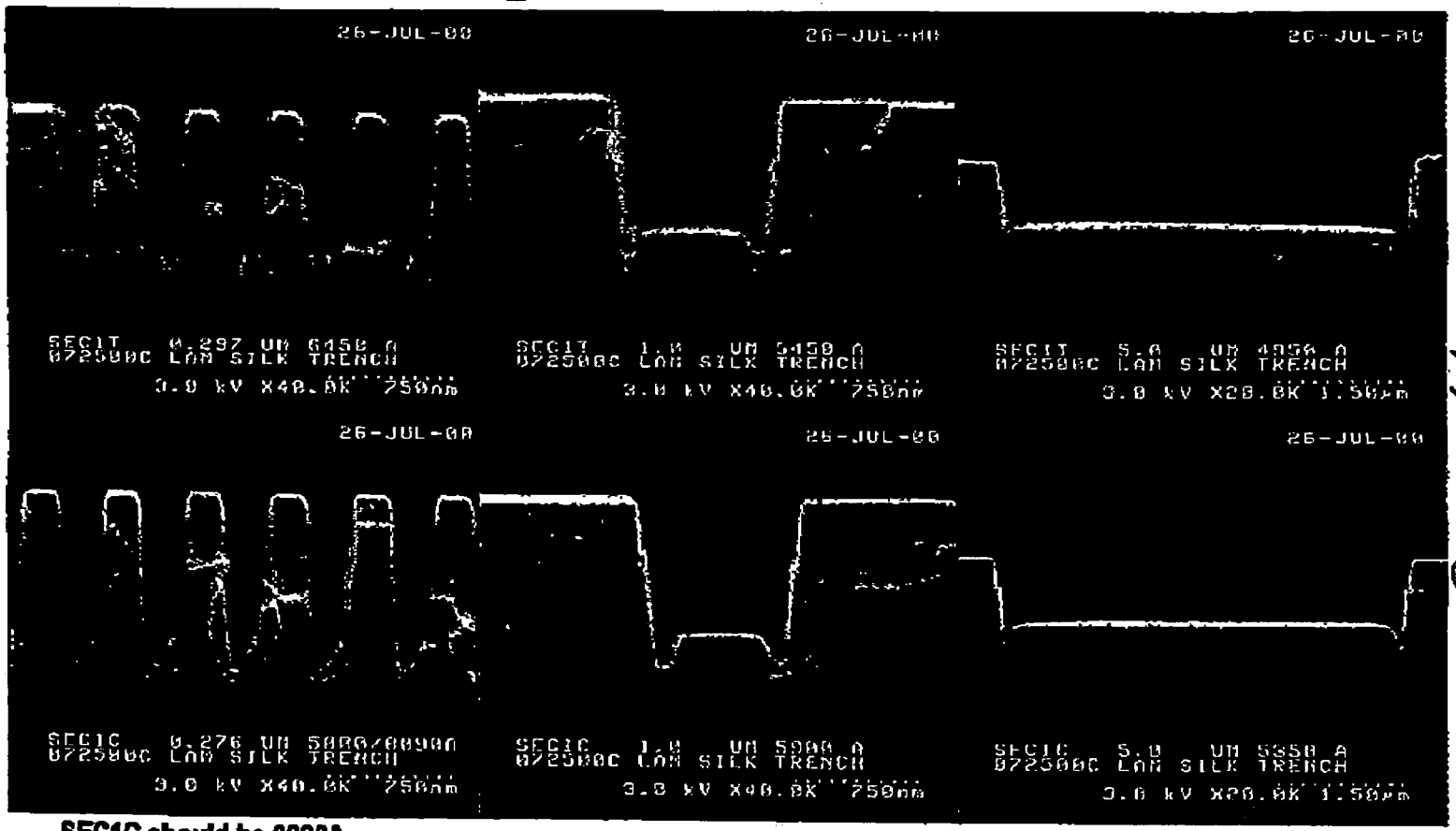


Wafer # 072500B (ESC @ 0°C) (45.9% Overetch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
160 mT/ 500/ 0/ 600 NH3/ 210" (PR Cleared @ 95")



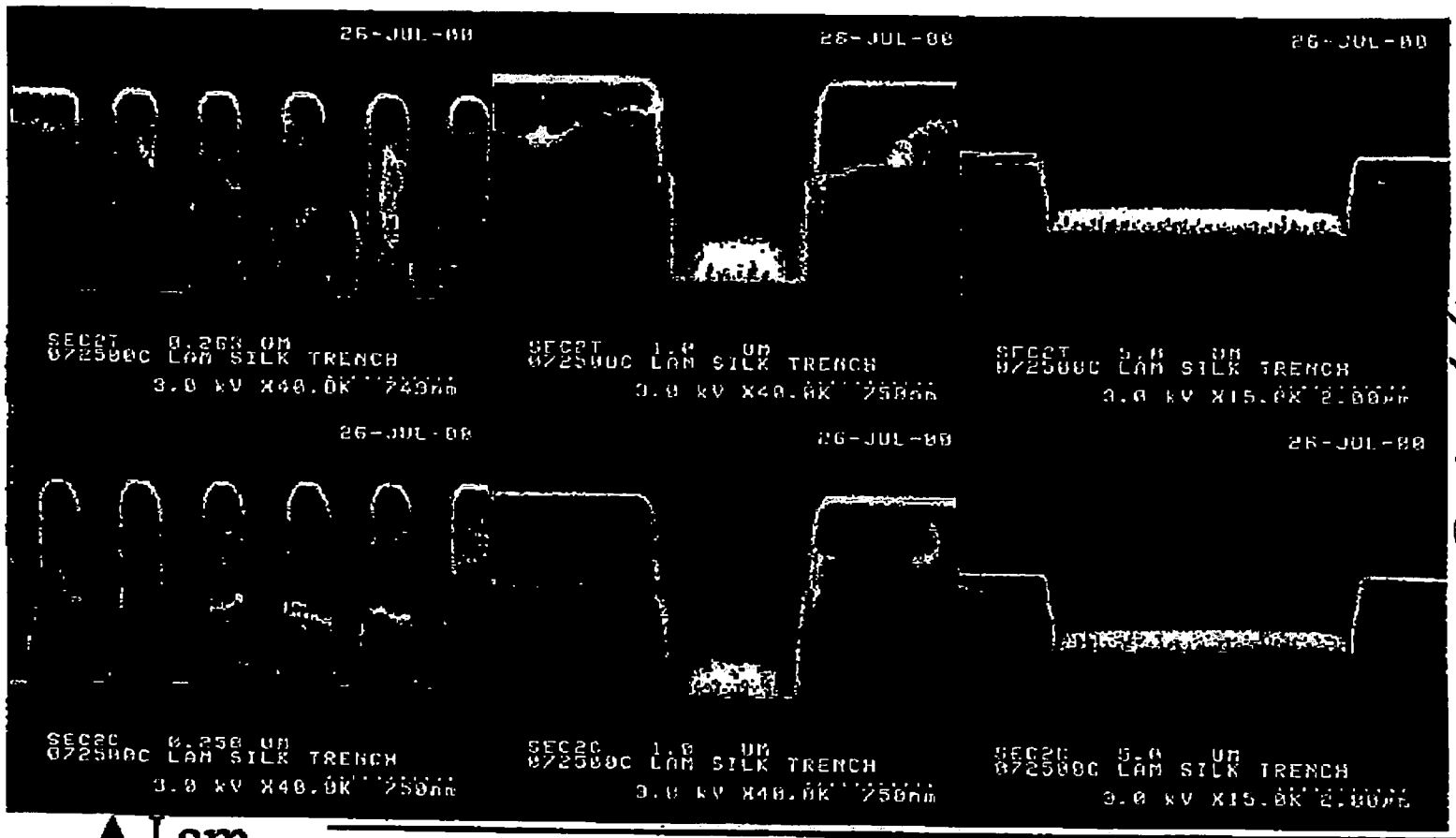
Wafer # 072500C (ESC @ 0°C) (Partial Etch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
160 mT/ 500/ 0/ 1000 NH3/ 95"

ER = 3853 A/min; ER Uniformity ≤ 4.0%; RIE Lag = - 18.3%



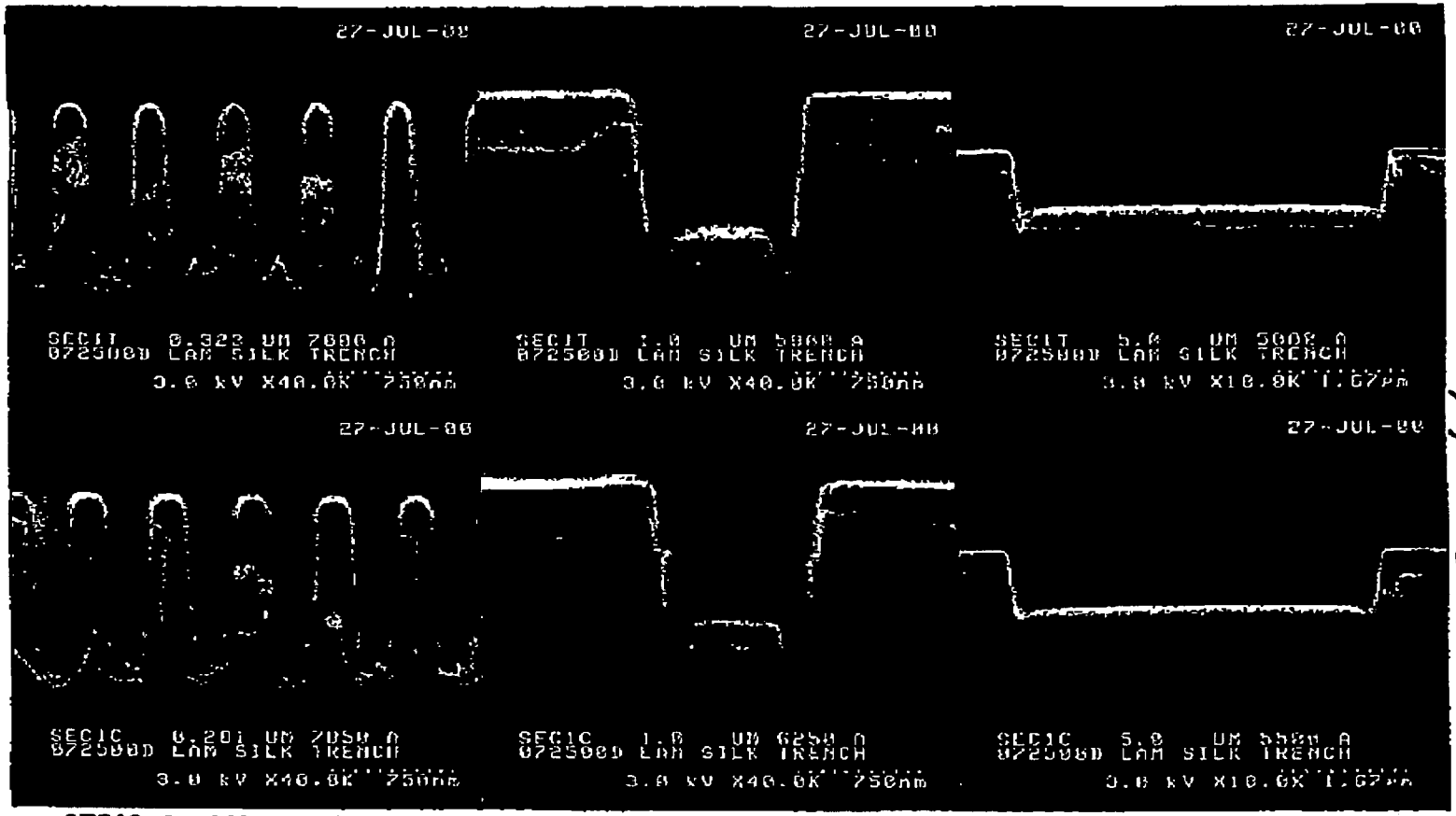
SEC1C should be 6600A

Wafer # 072500B (ESC @ 0°C) (16.3% Overetch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
160 mT/ 500/ 0/ 1000 NH3/ 172" (PR Cleared @ 84")



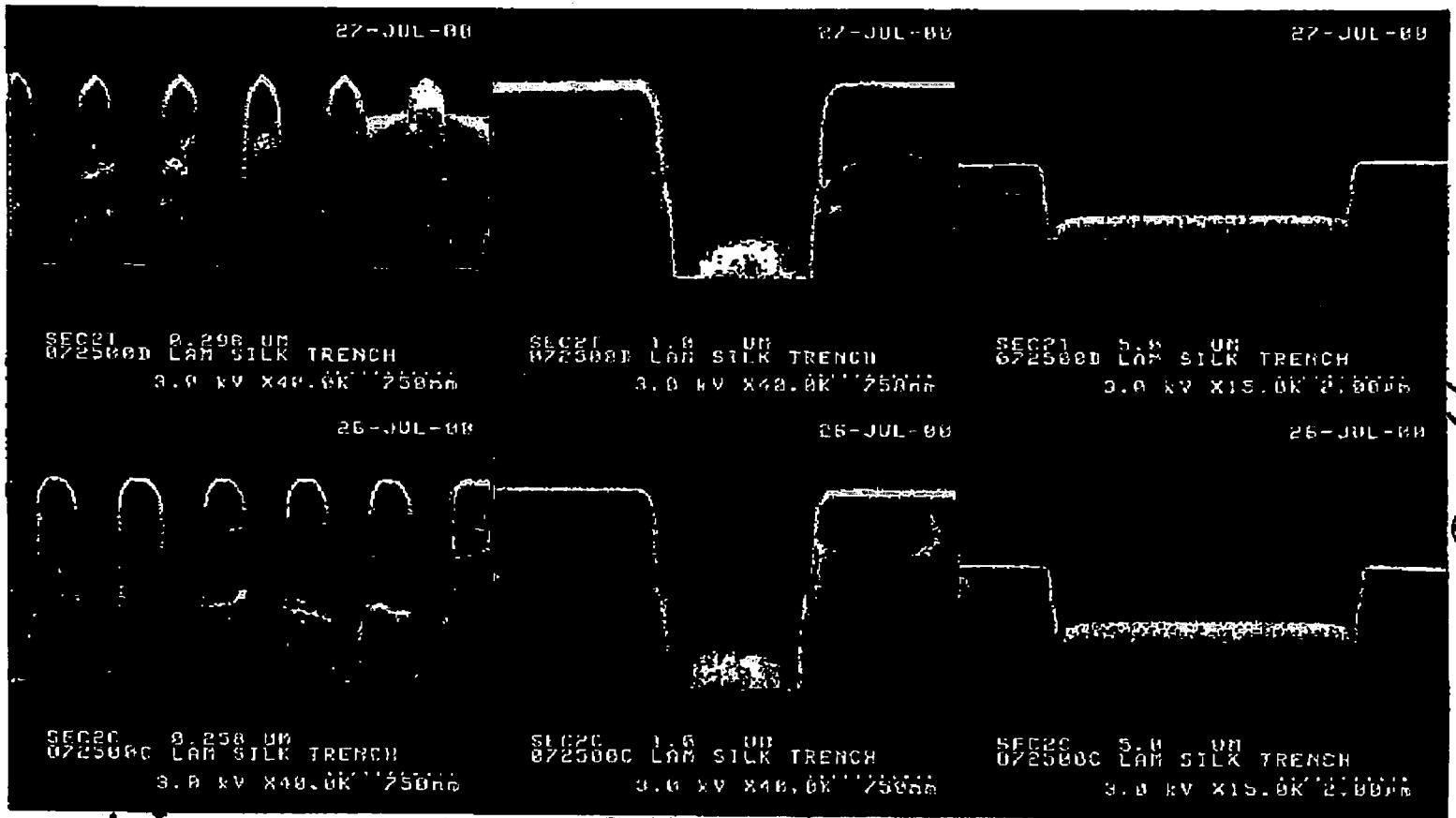
Wafer # 072500D (ESC @ 0°C) (Partial Etch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
100 mT/ 500/ 0/ 600 NH3/ 115"

ER = 3509 A/min; ER Uniformity ≤ 5.7%; RIE Lag = - 25.6%



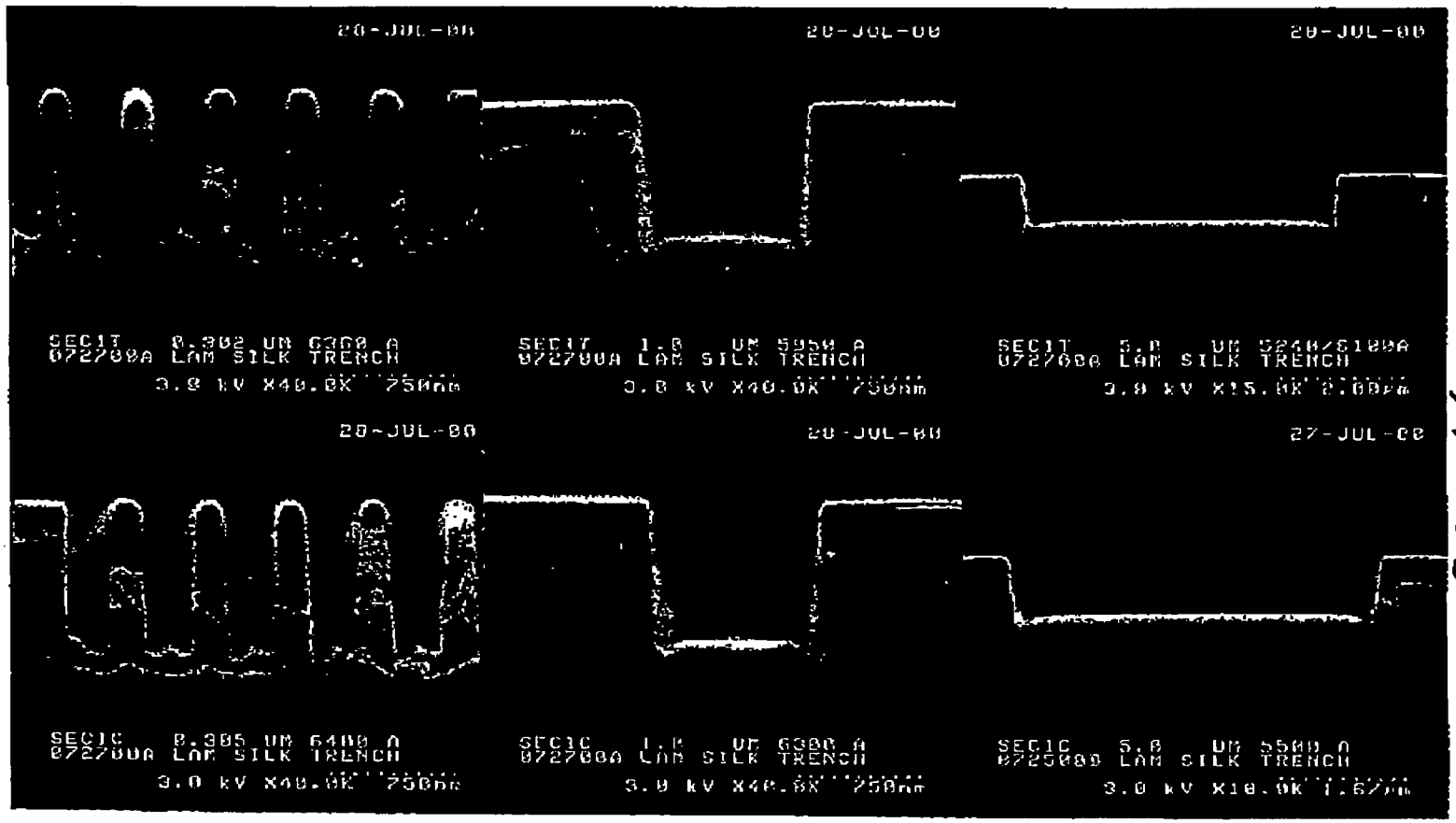
SEC1C should be 6600A

Wafer # 072500D (ESC @ 0°C) (29.3% Overetch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
100 mT/ 500/ 0/ 600 NH3/ 210" (PR Cleared @ 78")

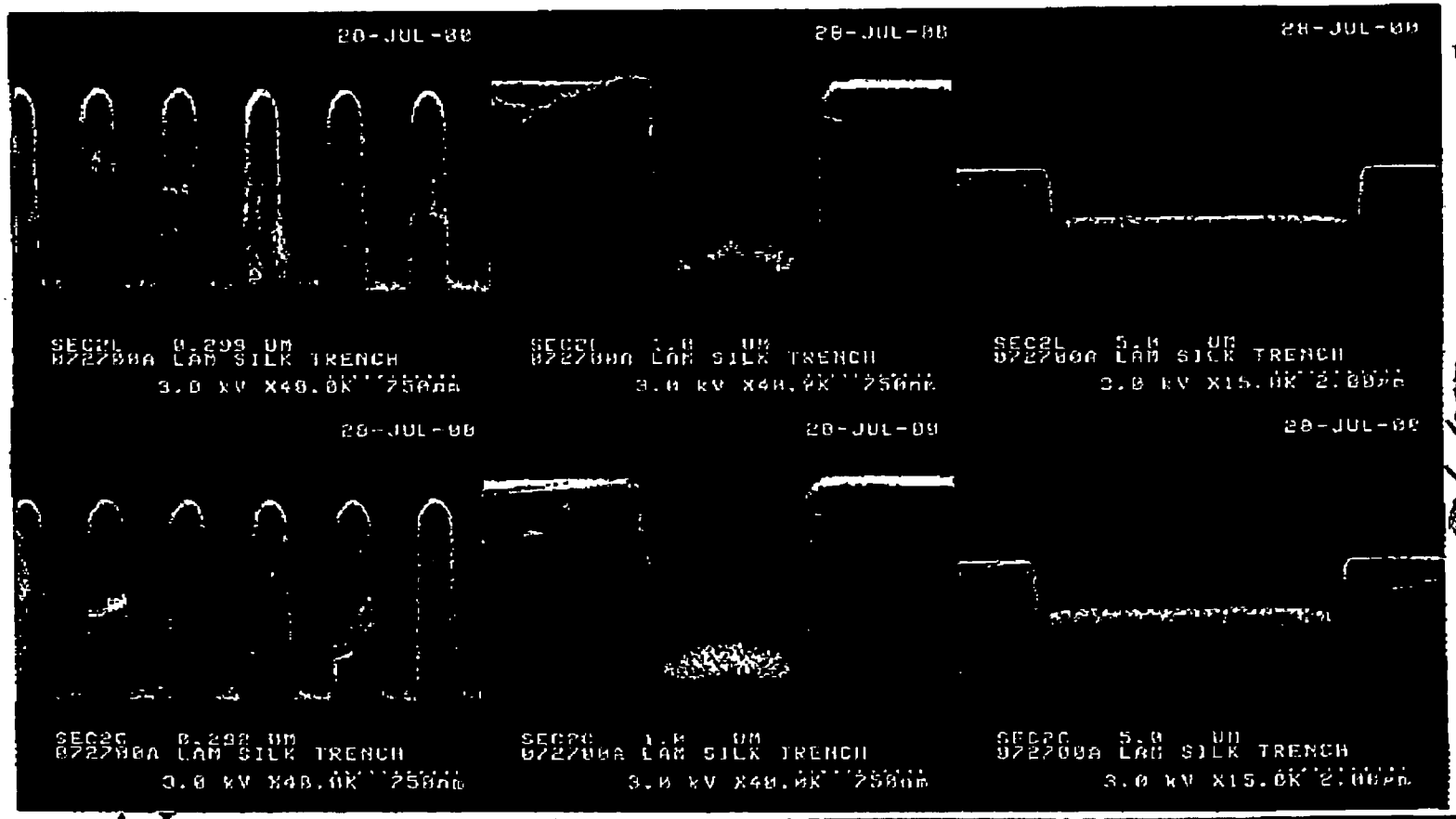


Wafer # 072700A (ESC @ 20°C) (Partial Etch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
160 mT/ 500/ 0/ 600 NH3/ 100"

ER = 3752 A/min; ER Uniformity ≤ 2.9%; RIE Lag = - 6.9%



Wafer # 072700A (ESC @ 20°C) (1% Underetch)
70 MT/ 500/ 1K/ 160 Ar/ 15 O2/ 5 C4F8/ 40 CF4/ 28"
55 mT/ 1400/ 1K/ 140 Ar/ 9 O2/ 15 C4F8/ 10"
160 mT/ 500/ 0/ 600 NH3/ 150" (PR Cleared @ 82")



SUMMARY

- ▲ Increasing NH3 Flow:
  - – Increases ER, decreases ER Non-uniformity, decreases RIE Lag
- ▲ Decreasing Pressure:
  - – Decreases ER, decreases ER Non-Uniformity, decreases RIE Lag
- ▲ Increasing ESC Temperature*:
  - – Decreases ER, decreases ER Non-uniformity, decreases RIE Lag